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PAR 243A

Briefing Print Enlarger (Prototype)

20 April 1966

Declass Review by NGA.

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PROJECT AUTHORIZATION REQUEST

SUBJECT: Briefing Print Enlarger (Prototype)

TASK/PROBLEM

1. Design, fabricate and test a prototype briefing print enlarger based upon tests and observations of the breadboard equipment developed on the combined PAR 202/224.

PROPOSAL

2. Introduction:

a. The PAR 202 effort was authorized to provide design studies and breadboard hardware to aid in the design of an enlarger for exposing 20- by 24-inch prints in the 10X to 60X range of magnification from roll form negatives. The PAR 224 authorization was for similar studies and breadboard hardware to aid in the design of an enlarger for 3X to 15X magnification from 70mm square portions of roll negatives with prints up to 40 x 40 inches on cut sheet stock. Both requirements were for either black-and-white or color prints.

b. As the work on the two projects progressed, it became clear that a single basic enlarger frame with a set of interchangeable lens and condenser sets could meet both requirements. The two projects were therefore combined and a single breadboard unit fabricated.

3. General Approach:

a. In this project, we propose to design, fabricate and test a prototype enlarger based upon the tests and observations of the design studies and the breadboard equipment produced in PAR 202/224.

b. Upon the basis of the arrangement of the breadboard equipment, including changes shown desirable by observation and test of that equipment, the enlarger design will provide for:

(1) A horizontal optical axis system with moveable print stock platen for negative-to-print distances from 50 to 80 inches.

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(2) The print stock platen, lens, negative gate and lamphouse rigidly coupled together by a massive steel structural member which in turn is isolated from troublesome building vibration by rubber-in-shear shock mounts.

(3) A family of six interchangeable lenses, each in its own focus assembly (including a negative gate glass), giving a range of magnification for black-and-white prints from 3X to 60X. Five of this family of lenses are suitable for exposure of color prints, providing a range of magnification from 3X to 39X.* The specification for magnification range, negative gate size, print size and high contrast resolution are shown in Section 3 of the attached Specification 469-333. Each of the lens assemblies will have a matching condenser lens assembly to be installed in the lamphouse.

(4) Acceptance of roll form negatives on flanged spools in widths from 70mm to 9.5 inches and with spool flanges up to 7.6 inches diameter (500 feet of 5.5 mil base or 1000 feet of 2.5 mil base film). The flanged spools will be engaged by a hole and keyway at the center of each flange like that described in Military Standard MS26565, 12 September 1962. Cut sheet negatives will be positioned in the gate by attaching leader and trailer or other handling "tab", if required.

(5) Illuminated scales, for the measurement of in-frame coordinates on the negative in which one unit represents one millimeter and the least count is no larger than two millimeters. The scales will be located to be more easily readable than in the breadboard model.

(6) A film viewer for previewing the negatives and finding frame numbers in a roll of negatives before placing the negative into the printing gate. The viewer will also have fiducial marks to aid

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*A lens design was made and a sample built on PAR 224 to provide 40X to 60X color enlargement. This f/4 design does not give as good image quality for black-and-white printing as does the f/2.8 lens designed specifically for blue portion of the spectrum. If color enlargement in the 40X to 60X range is occasionally required, a seventh focus assembly for the f/4.0, 1.25-inch EF color lens should be authorized.

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in setting zero and in identifying specific images with the in-frame coordinate scales.

(7) Negative roll winding, rewinding and stopping controlled by a "joy-stick" with a squeeze-action switch. Squeezing of the switch will actuate the torque motor and release the brake on each film spindle, and moving the joy-stick side-to-side will change the relative torques applied to the spindles, to control direction and speed of film traverse. Release of the switch will apply a brake on each spindle and, after a short delay to assure that the spindles are stopped, turn off the torque motors. One thousand feet of film can be wound from one spool to another in less than 3.5 minutes.

(8) Holding the negative between precision glass plates at the printing gate for control of flatness and focal position. A small quantity of index matching fluid can be injected between the film and the gate glass on each side of the film to mask light scratches, remove dust and lint and to eliminate Newton's rings. The fluid gate closing mechanism will be simplified from that used in the breadboard model. The fluid injection pumps will be changed to deliver more fluid into the gate or other changes introduced as required to reduce the likelihood of air bubbles in the field of view.

(9) A more efficient ventilation system for removal of immersion fluid fumes than that in the breadboard model. Arrangement for the collection of liquid overflow from the gate and disposition of its fumes will be made.

(10) Means to evaporate or remove the fluid from the film after opening the gate before it is possible to wind that film section into either spool.

(11) Forced cooling of the lamphouse and filters. The cooling air will be filtered to reduce dirt accumulation on the condensers, lamp, etc.

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(12) Making the correct lens focus setting for projection through the negative film base, with various base thicknesses, in addition to the emulsion-toward-lens condition. Provision will also be made to facilitate setting the correct focus for color prints in the same conditions. The focus digital indicator will be repositioned to facilitate reading.

(13) Exposure prediction and adjustment to be accomplished by a spot probe easel photometer with (desirably) a three-millimeter aperture. The photometer probe will be mounted on a special base to be held and released quickly from the vertical vacuum easel face (see item (14), below).

(14) Print stock platen design providing vacuum holding of cut sheet (in sizes of 8 x 10 inches and larger) at any position or orientation over its entire 41 x 41 inch surface. Accessory gasketed metal or plastic strips with a quick release mechanism will be provided to hold down the edges of strongly curled print stock. Provision will be made for an opaque diffuse white surface for observation of the projected image.

(15) Revised mounting system for the objective lens and focus assemblies to provide safer, more rapid interchange of lens assemblies than the system used in the breadboard. The readability of the focus indication counter on the various lens focus assemblies will be improved. The basic principle of manual setting of the lens focus to a tabulated value displayed in a mechanism coupled to the platen position drive will be used as demonstrated in the breadboard model.

(16) Increased speed capability of the vertical movement of the negative transport system. In order to allow precise positioning of the film and to allow removal of immersion fluid from the film as it is withdrawn upward from the gate, it may be necessary to make this drive variable speed.

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(17) A three-position filter wheel in the lamphouse with provision to:

(a) Position any of the three filter apertures in the beam, using controls on the console, for either viewing, projection, or timed exposure, or

(b) Advance the three filters in sequence with equal timed exposure through each.

The filter wheel and the filters will be designed for convenient interchange of the filters. Three separate variable auto-transformers will be mounted on the control console with circuit provision to power the printing lamp by a particular transformer for each of the three filter wheel positions. With this arrangement several printing modes will be possible:

Mode 1: With a red, a green and a blue filter in the filter wheel, a color print may be exposed by the "sequential-tricolor" technique.

Mode 2: With a blue filter, Wratten 98 (W98), or other suitable filter, and an orange or red filter in the wheel, Kodabromide paper, Fine Grain Positive Film or other "color-blind" print stock may be exposed through the blue filter for optimum image quality and the orange or red filter used to project a non-actinic image for visually positioning the print stock.

Mode 3: With a series of "Polycontrast" (PC) filters in the filter wheel, Polycontrast paper may be exposed at the desired contrast grade by selecting the appropriate filter wheel position from the console. Preliminary tests indicate that the correction of the various lenses is probably adequate to provide image quality on Polycontrast paper almost equal to that on Kodabromide exposed through a W98 filter. Tests must be made before this can be

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stated without qualification. The PC filters have high transmittance in the red portion of the spectrum, therefore, placing a red filter in the enlarger beam with a PC filter in the lamphouse can probably provide a non-actinic projected image on the easel for positioning the sheet of Polycontrast paper.

(18) A set of well integrated controls for the negative transport, magnification and focus setting, exposure prediction, and exposure making to speed production and reduce errors. To avoid damage to the negative, interlocks will be provided to prevent movement of the film when the negative gate is closed.

PROGRAM OBJECTIVES

4. In the proposal for PAR 243 presented in November 1965, the program plan was developed to provide a single, usable prototype enlarger. Since that program was presented, the project requirements have been changed by:

a. The changes of design parameters arising from observation and test of the breadboard enlarger, and

b. An interest in the fabrication of multiple prototype enlargers. The program objectives presented here provide for fabrication and delivery of the single, usable prototype enlarger authorized 15 Dec 65 at the earliest possible date, and will facilitate follow-on fabrication of a quantity of two to five additional prototype enlargers on another contract. The fabrication of the additional quantity will thus derive some benefit from the experience in parts fabrication and some subassembly of the first unit.

5. Revise the enlarger concept and design from that of PAR 202/224 breadboard model as described in Section 3.b.

6. Make drawings and a parts list for a production design Briefing Print Enlarger.

7. Fabricate parts and assemble one prototype enlarger as rapidly

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as completion of drawings permits. Objective lenses and condenser elements from the breadboard model will be transferred to this prototype model.

8. The breadboard model will be kept in functional condition to:

a. Aid the engineering effort by providing means to test design concepts.

b. Provide a test stand for testing lens sets for the expected additional prototype enlargers ahead of the completion of their mechanical and electrical assembly.

9. Complete the assembly, make focus calibration runs, and test the prototype enlarger in the contractor's facility.

10. Provide two copies of an operating manual for the enlarger.

11. Provide a final report of the prototype design and fabrication effort following delivery of the first enlarger.

12. Install and check out the enlarger at the designated facility. The installation schedule and accompanying cost estimate are based on timely preparation of the site and availability of necessary services and personnel. The services include the capability to process cut sheets of photographic paper and film.

SCHEDULE

13. Our current estimate of the major phases of effort to provide the first prototype is shown in Figure 1, Tentative Schedule. This estimate is based upon consideration of the design changes described in Section 3.b. The contractor was authorized on 13 December 1965, to proceed on this program and this statement is our current estimate of its completion.

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TENTATIVE SCHEDULE

Briefing Print Enlarger (Prototype)

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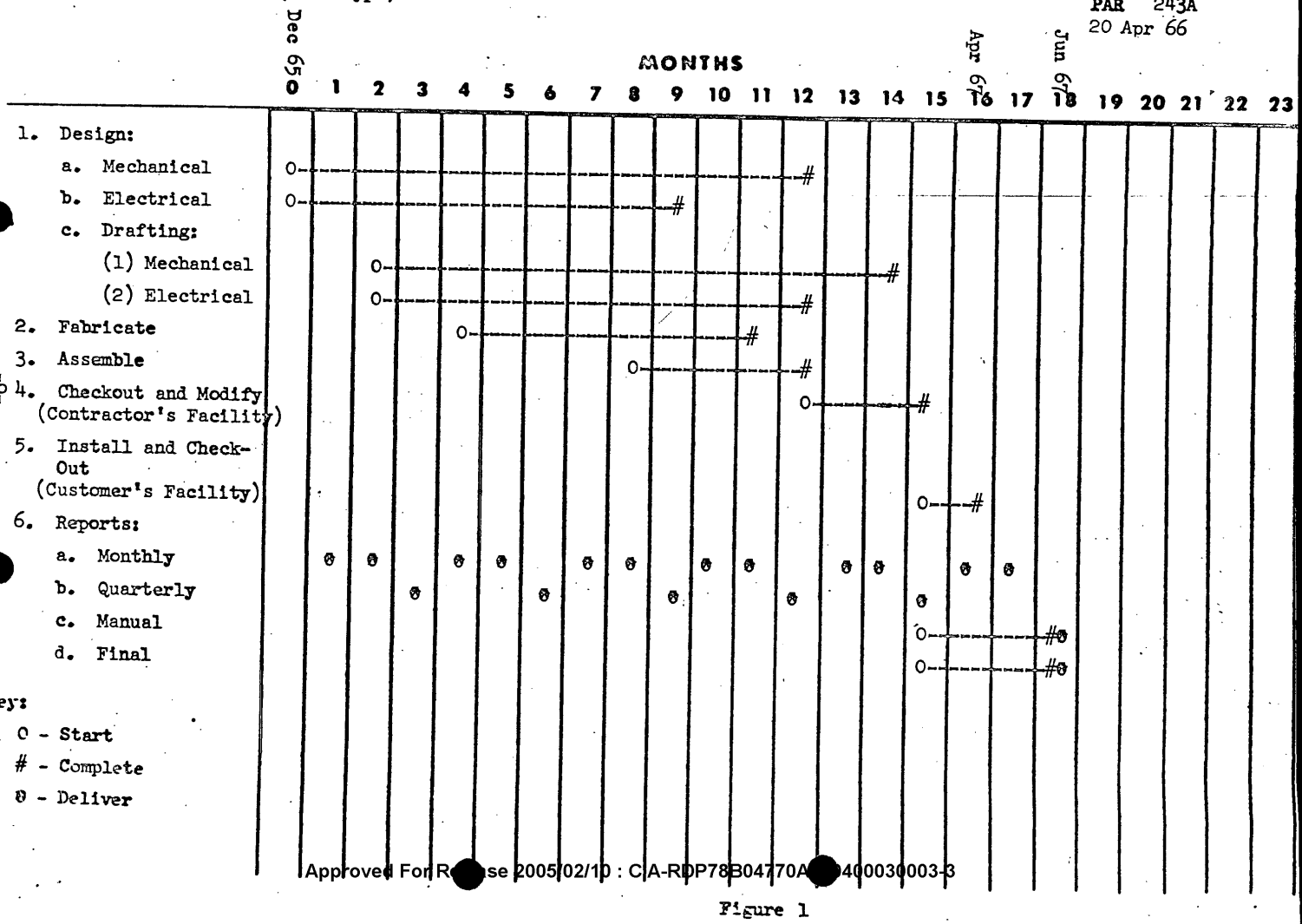

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Figure 1

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Preliminary Specification - Briefing Print Enlarger - (No. 469-333)

PREFACE

The following tentative specification was prepared prior to completion of tests of the breadboard model enlarger and during the process of design studies for the prototype enlarger. Some pertinent specification data have been omitted for lack of information. It may also be necessary to revise other items as more information becomes available.

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1. Equipment Application

The enlarger is designed for rapid, convenient production of large photographic prints for unaided visual observation, as in group briefing or for report illustrations, from high-quality aerial photographic negatives in roll form.

2. Description

2.1 The enlarger has a horizontal optical axis with a moveable print stock platen to provide a range of negative-to-print distance from 50 to 80 inches. The print stock platen, lens, and negative gate are rigidly coupled together by a massive steel structural member which is, in turn, isolated from environmental vibration by rubber-in shear mounts.

2.2 The print platen surface is 41 inches square and provides vacuum holding for cut sheet print stock at any position on that surface.

2.3 A magnification range of 3X to 60X, with the range of negative-to-print distance described above, is achieved for black-and-white prints with a specially designed set of six lenses. The focal lengths of these lenses were chosen to provide a continuous range of available magnification, as shown in Table I, page 12. Five of the six lenses are also suitable for color printing, providing magnification from 3X to 39X for color prints. To provide the necessary focus accuracy, each lens is mounted in its own focusing assembly, including a negative gate glass.

2.4 The required focus setting for each of the six lenses for various negative-to-platen distances (steps of 0.2 inch through the 50 to 80 inch range) is displayed in a mechanism coupled to the platen drive to show only the focus setting and magnification for the particular lens and negative-to-print distance which exists. The lens focus is set manually to make the focus indication counter on the focusing assembly agree with the displayed value from the tabulation.

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TABLE I

BPE Specifications for Nominal Magnification, EFL, and f-number and for Minimum Axial Resolution and Field Diameter

Nominal Magnification		Lens		Minimum Axial Resolution		Minimum Field Diameter	
M (Diameter)	OAC (Inches)	EFL (Inches)	f-Number	Negative (1/mm)	Print (1/mm)	Negative (Inches)	Print (Inches)
2.95	57.	10.75	f/17.8	80.	27.	3.7	10.9
3.77	65.				21.		13.9
5.24	80.				15.		19.4
4.75	50.	7.17	f/12	113.	23.	3.7	17.6
6.48	62.				17.		24.0
9.04	80.				12.		33.4
8.46	50.	4.85	f/7.8	200.	23.	3.7	31.3
11.0	62.				18.		40.6
14.7	80.				13.		54.4
14.5	50.	3.06	f/5	320.	22.	2.10	30.5
18.5	62.				17.		38.8
24.4	80.				13.		51.1
24.5	50.	1.90	f/4.2	400.	16.	1.24	30.4
30.8	62.				13.		38.2
40.3	80.				10.		50.0
38.5	50.	1.24	f/2.8	550.	14.	.79	30.4
48.2	62.				11.		38.1
62.7	80.				9.		49.5

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2.5 The illumination is produced by 300-watt tungsten projection lamps with condenser lenses. A separate condenser and lamp assembly is provided for each objective lens and the assemblies are designed for convenient interchange in the lamphouse.

2.6 A three aperture filter wheel whose position is selected from the control console is provided in the lamphouse. The filters are readily interchangeable to provide for optimum exposure conditions for a variety of print materials.

2.7 Exposure control is accomplished from a caster mounted control console coupled to the main enlarger frame by an electrical cable. Exposures are started and ended by turning the projection lamp ON and OFF. The time exposure is controlled by a decade timer on the console, for times up to 111 seconds in 0.1 second steps. (Effective exposure is proportional to exposure time for exposure time greater than two seconds). Irradiance level in the projected image is controlled by adjusting the voltage applied to the lamp. Three variable autotransformers are mounted on the console and are connected such that a particular transformer supplies power to the lamp for one position of the filter wheel. Provision is made for extended time projection through any of the filter positions for image observation or photometer measurement of the projected image. Timed exposures may be made through any of the three filters as selected at the console or through all three in sequence with the same time of exposure for each.

2.8 The roll-negative transport system winds the web horizontally between the two spindles mounted with their axes approximately vertical. The transport system is moveable up and down by a motor drive to place the film in front of a viewer or to lower it into the negative gate with the ability to place any point on the width of the web at the optical axis. Negatives 70mm to 9.5-inches wide mounted in flanged film

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spools (MS26565, 12 Sept 62) up to 7.6 inches in diameter can be mounted on the transport.

2.9 In the negative gate, the film is clamped between glass plates under spring pressure to hold it in the correct focal plane. As the gate is partially closed, a small quantity of index matching fluid (tetrachloroethylene) may be injected on each side of the film which wets the film and glass surfaces over the gate area upon full closure of the gate.

2.10 Interlocks are provided to prevent moving the negative while it is clamped in the gate. A ventilation system is provided to remove the fumes of the immersion fluid to an outdoor exhaust. After the gate is opened, the transport system must be driven upward to move the wet film area past a liquid removal unit before it is possible to wind the film by motor drive into either spool.

2.11 An easel spot photometer is provided to aid in predicting correct print exposures for black-and-white or color materials.

2.12 A coordinate measuring system is provided to position images in the printing gate which are described to the operator by coordinates of position within a given numbered frame of the roll of negatives. The unit of coordinate measurement in the system is one millimeter.

3. Performance.

3.1 The nominal values of magnification (M), effective focal length (EFL), and relative aperture (f-number), are given in Table I for the six lenses. The magnification achieved for a given negative-to-print distance (OAC) may vary ±2% for various lenses of a production lot. The magnification value shown in the focus table may be in error by ±1% from the true value.

3.2 The Minimum Axial Resolution specification of Table I shall be applied to tests made in the following manner.

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3.2.1 The test target material shall have at least 100:1 contrast, be in the USAF 1951 or USAF 1962 format and provide 80 to 800 lines/mm. The material shall have been exposed on Kodak Type 649GH film on the Microscope Resolution Target Camera at the contractor's facility. The test target polarity will be clear lines in a high density background.

3.2.2 Test prints on the BPE are to be exposed on Kodak Fine Grain Positive Film (or on equal product) with a Wratten 98 (W98) blue filter in the lamphouse filter position.

3.2.3 Resolution performance will be judged as the highest spatial frequency in the test target whose image is visually resolved in the print. The criteria for judgment of image resolution shall be those of ~~the proposed ASA standard on resolution of sensitized materials.~~ 3.6.2 MIL STD 150A.

3.2.4 An exposure series may be exposed to obtain the optimum resolving power. The lens focus setting shall be that predicted by the focus table.

3.3 The off-axis resolving power shall be measured at the same focus and exposure which provided the axial resolution data and to the same criteria. The same type of test target material shall be used, preferably on a common piece of film. The average of radial and tangential resolving power for four radii of the field of view, separated by 90°, at a radial distance of 70% of the full field radius, shall be no less than 70% of the resolution measured on-axis.

3.4 The Minimum Field Diameter at the negative, as specified in Table I, is primarily controlled by the various aperture diameters in the condenser system. The field diameter at the print is determined by the field diameter at the negative and the magnification. The specified field diameter at the print shall be measured with the negative-to-print distance adjusted to produce the corresponding magnification given in the first column of Table I.

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3.5 The temperature of a photographic density sheet having density of 1.0 shall not exceed _____*°F at the stable level. An iron-constantan thermocouple junction will be attached with clear cement to the emulsion surface of the density patch and the assembly clamped in the dry negative gate with the emulsion side away from the lamp.

3.6 The enlarger (4.80-inch lens, on-axis) shall provide, with the W98 filter, exposure in thirty seconds on Kodabromide F2 paper to produce 0.1 density above fog level through a density of _____* (ASA diffuse density) in a Kodak Photographic Step Tablet with the W98 filter and the lamp operating at its rated voltage for 25-hour life.

3.7 The illuminance in the projected image of an open gate shall not decrease below _____*% of that on the axis at a point 0.8 of the maximum field radius from the axis.

4. Environment

4.1 The BPE must operate in a photographic darkroom with safelights suitable for the print stock being exposed. All lights in the enlarger will be enclosed, shielded, or provided with intensity controls to avoid unwanted exposure of the print stock.

4.2 The workroom should be clean and maintained within the temperature and humidity range required for dry handling of photographic print stock. It is highly desirable, though not mandatory, that the enlarger not be installed in a "wet" darkroom to avoid the associated high humidity, chemical fumes and dust, etc. which may corrorde precision mechanical parts of the instrument.

*Data to be supplied by contractor.

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5. Space and Service Requirements

5.1 The floor space requirements are shown in Figure 2. The control console is caster mounted for convenient movement according to the operator requirements.

5.2 The electrical power input to the enlarger is by a three-conductor cord at 117V AC, 60 cycles/second, single phase, with _____* amps maximum current.

5.3 A _____* inch diameter flexible tube carries the immersion fluid fumes from the negative gate and should connect to an outside vent. A blower is mounted on the enlarger to create a moving air current for this purpose but an additional blower should be installed or other provision made to prevent reversal of the air flow by back pressure from the outside vent.

5.4 A seven-inch diameter flexible tube is the exhaust line for the vacuum platen. A separate blower assembly enclosed in a soundproof enclosure is supplied with the enlarger. This blower is capable of providing a vacuum head of about 0.5 psig with air flow rate from 50 to 600 CFM as required for proper functioning of the vacuum platen. The blower assembly may be mounted wherever convenient to allow connection to the back of the print stock platen with up to ten feet of flexible tube. Electrical power input to the blower is 3-phase AC at standard voltage ratings with current level as required for operation at about 2.5 hp.

5.5 For moving the enlarger, a set of removable castered jacks is available for attachment to the four legs. With the vacuum platen removed, the maximum width of the enlarger is 34-inches, permitting passage through a 36-inch door, usually without removing the door from the frame provided perpendicular access to the doorway is possible.

*Data to be supplied by contractor.

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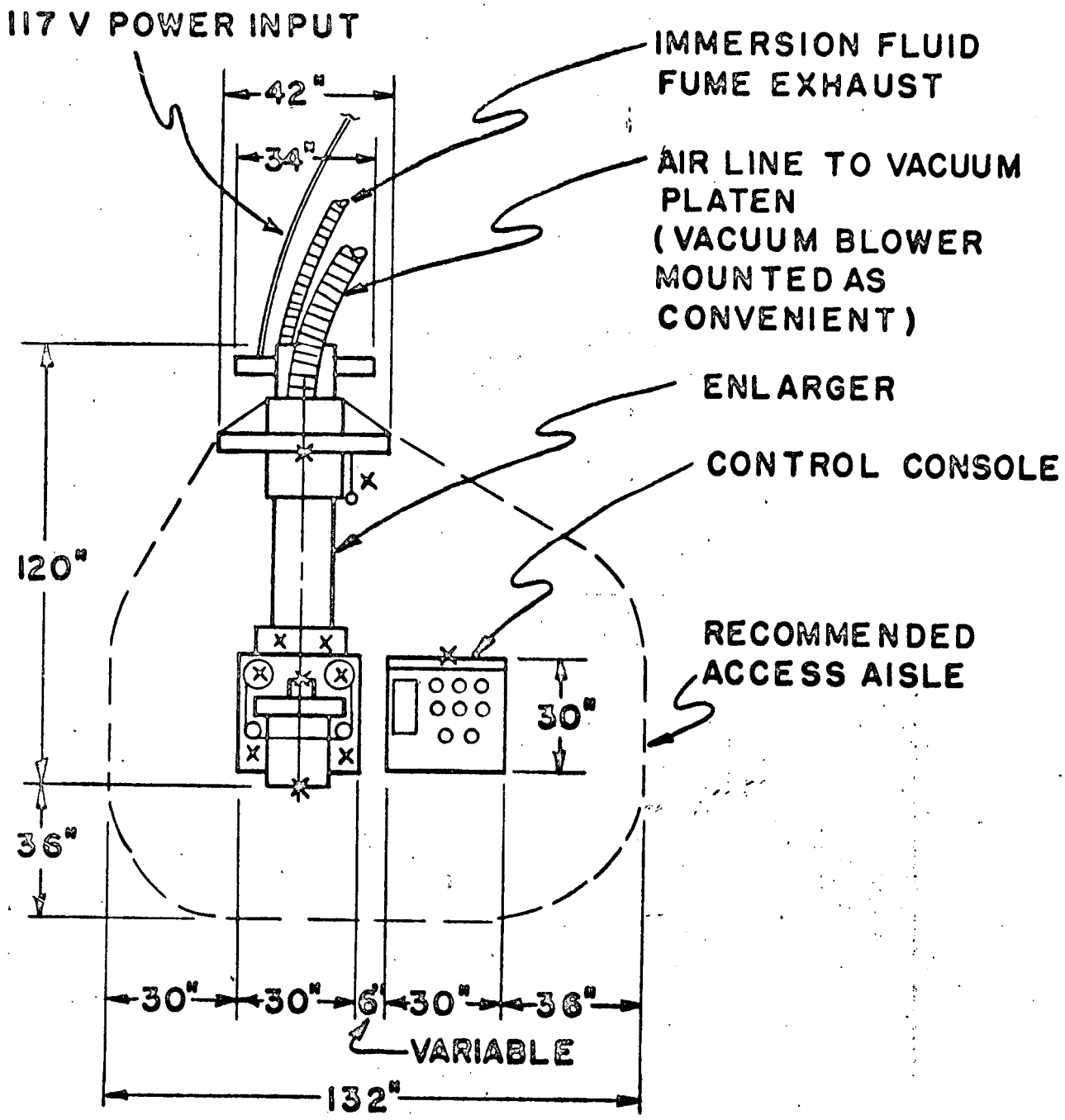

Figure 2. Floor Space Requirement for Briefing Print Enlarger. (Operator Access is Required Frequently at the Areas Marked "X".)

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